Learning Objectives:
- Differentiate the ionic basis and characteristics of graded potentials and action potentials
- Explain the significance of the absolute refractory period

QUIZ/TEST REVIEW NOTES
SECTION 5 NEUROPHYSIOLOGY
[GRADED AND ACTION POTENTIALS]

1. CHARACTERISTICS OF ACTION POTENTIAL [spikes]
   a. Action potential defined
      - Rapid electrical signals that travel long distances without losing amplitude
      - Large constant-strength depolarization’s that travel long distances without losing strength
      - Occur when voltage-gated ion channels open altering membrane permeability to Na and K
      - Three phases:
        (1) Rising phase (2) Falling phase (3) After-hyperpolarization phase
      - Amount of neurotransmitter released at axon terminal is DIRECTLY related to total number of action potentials that arrive at the terminal per time
      - One action potential does not alter ion concentration gradients
      - CANNOT OVERLAP and cannot travel backward because of their refractory periods
   b. Characteristics
      - The graded potential strength that initiates the action potential has no influence on the amplitude of the action potential
      - All or none phenomena because either occur at maximal depolarization (suprathreshold) or do not occur at all (subthreshold)

2. IONIC BASIS OF AN ACTION POTENTIAL
   a. Voltage-gated Na-Channels [rising phase]
      - When membrane depolarizes to suprathreshold voltage-gated Na channels open
      - Once voltage-gated Na channels are open membrane much more permeable to Na
      - Na Ions move into cell for two reasons
        (1) Na moves with concentration gradient from E.C.F \( \rightarrow \) I.C.F. [high-low]
        (2) Negative membrane potential inside cell attracts positively charged ions
      - Time sensitive gates
      - Na-Chanel Positive feedback loop

Extra Knowledge on Voltage Gated Na Channels
1. Na Channels in Axon have Two Gates
   a. Activation Gate
      - At resting membrane potential it is closed and no Na moves through channel
      - Depolarization = Activation swings open allowing Na to move into cell down electrochemical gradient
      - Addition of positive charges start a positive feedback loop
   b. Inactivation Gate
      - At resting membrane potential (amino acid sequence) on cytoplasmic side of channel is open
      - Major role in turning off positive feedback loop
      - Amino acid inactivation gate re-attaches to cytoplasmic channel end halting entry of Na

TURN PAGE OVER FOR DIAGRAM
b. Voltage-gated K-Channels \([\text{falling phase}]\)

- Start to open in response to depolarization but K channel gates are much slower to open
- When K channels are open the membrane potential of cell has reach +30mV because of Na influx through faster-opening Na channels
- K channels have just finished opening at peak of action potential making the membrane very permeable to K
  [Going with electrochemical gradient K moves towards E.C.F. hyperpolarizing cell]
  [Hyperpolarizing cell to approx. -90mV the voltage-gated K channels close returning ion permeability and resting membrane potential]

General Theme
- Influx Na = Depolarization
- Efflux K = Hyperpolarization
c. Role of the Na/K ATPase:
- Ions that do move into or out of the cell during action potentials are rapidly restored to original compartments by the Na-K-ATPase (Sodium Potassium Pump)
- Pump uses energy from ATP to exchange Na that enters the cell for K that leaked out of it
- Maintains concentration gradients of Na and K across cell membrane
- Pumps 3 Na out and 2 K into cell

d. Refractory Periods
- Once action potential has begun a second action potential cannot be triggered for about 2 msec, no matter how large of a stimulus
- Regulate Action Potentials so no overlap or backward travel occurs
- Limit rate at which signals can be transmitted down neuron

a. ABSOLUTION REFRACTORY PERIOD
- No action potentials allowed for 2 msec
- Represents time required for Na channel gates to rest to their resting positions
- Ensures that a second action potential will not occur before the first has finished

b. RELATIVE REFRACTORY PERIOD
- Follows the absolute refractory period
- During this time Na channel gates have reset and show different potentials
  (a) Some returned to normal threshold = normal threshold for A.P
  (b) Some still not returned to resting position = Higher then normal threshold for A.P
- If any action potential does fire during this period it will have smaller amplitude than normal because K channels still open so depolarization is offset by K loss